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Sex Reversal in *Ostrea virginica*

Author

A. Berkeley Neidler

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Sex Reversal in Ostrea virginica

Alfreda Berkeley Needler.

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Since 1930 some observations on sex ratios of oysters living under natural conditions have been carried on and these were continued in 1934. Each year a number of oysters of known sex have been marked so that there is now a record of the sex of these oysters over several years. Experiments have been carried out to determine the effect of crowding on sex change. The records of these three phases of the work are given below.

Sex ratios in oysters of known age.

In 1929 the Totten bed, near the Prince Edward Island Biological Station, was planted with spat and since 1930 a sample of these oysters has been examined each year. The number examined in 1934 was small since fishing had started on the bed the previous autumn, and it was difficult to find many of the original oysters, but it is well worth noting in connection with previous records. Practically all the oysters spawned each year except in 1930, when only 19% were mature, but in a few the sex could not be determined and these are recorded as "?". As it will be impossible to continue these observations it is worth while to summarize all the findings since 1930 and this is done in the following table:

Table 1. Sex ratios in 1929 spat on Totten bed.

| Year | Total number examined | Percentage of each sex. |    |   |    |
|------|-----------------------|-------------------------|----|---|----|
|      |                       | ♂                       | ♀  | ♀ | ?  |
| 1930 | 167                   | 17                      | 2  | 0 | 81 |
| 1931 | 500                   | 62                      | 25 | 1 | 12 |
| 1932 | 157                   | 43                      | 25 | 4 | 1  |
| 1933 | 115                   | 33                      | 85 | 0 | 2  |
| 1934 | 46                    | 22                      | 76 | 2 | 0  |

This table shows plainly that the proportion of females to males has been steadily increasing. This would probably continue although there might always be a few males, as male oysters believed to be of considerable age have been found on natural beds.

In 1930 a number of spat settled on the 1929 spat on Totten bed. In 1932 some of these oysters were examined and it was found that there were very few females. By 1933 the ratio was much less striking and in 1934 it was normal. The results are summarized in Table II.

Table II. Sex ratios in 1930 spat on Totten bed.

| Year | Total number examined | Percentage of each sex |    |                |    |
|------|-----------------------|------------------------|----|----------------|----|
|      |                       | ♂                      | ♀  | ♀ <sup>2</sup> | ?  |
| 1932 | 83                    | 86                     | 5  | 1              | 8  |
| 1933 | 86                    | 62                     | 37 | 11             | 00 |
| 1934 | 88                    | 34                     | 66 | 00             | 0  |

In 1932 it was suggested that the peculiar ratio might be due to the close proximity of older females, especially as growth and health seemed to be quite normal. But whatever the factor was it only retarded and did not inhibit the change from male to female. Other experiments do not support the idea that the proximity of females has any great effect, although crowding may be a factor, and the above observations are still not satisfactorily accounted for.

Changes in individual oysters of known sex.

Since 1930 the sex of a number of oysters has been determined each year by boring a small hole in the shell of each and extracting the contents with a pipette. Some of these were not marked individually but some were in recorded groups, or were embedded in cement blocks in such a way that the valves could open freely. In these cases it was possible to keep track of the sex of the individual oysters over several years.

Only one oyster has survived since 1930. It was then recorded as a female about five years old and it has remained female ever since.

Of those determined in 1931 there were 25 still alive in 1934. In eight of these it was impossible to determine the sex for at least one year of the four. The sex of the remaining oysters is recorded in the following table.

Table III. Change of sex in oyster marked in 1931.

| Number | <u>Sex from year to year.</u>       |
|--------|-------------------------------------|
| 8      | Male every year.                    |
| 2      | Female every year.                  |
| 2      | Female to female to male to male.   |
| 1      | Female to female to male to female. |
| 1      | Male to female to male to male.     |
| 1      | Male to male to male to female.     |
| 2      | Male to female to male to female.   |

Some of the oysters whose sex was determined in 1932 were in groups and some embedded in concrete blocks but they may as well be recorded together. In eleven oysters it was impossible to determine the sex for one year of the three. The changes in sex of the remainder are summarized in the following table:

Table IV. Change of sex in oysters marked in 1932.

| Number | <u>Sex from year to year.</u> |
|--------|-------------------------------|
| 31     | Male every year.              |
| 7      | Female every year.            |
| 10     | Male to female to female.     |
| 3      | Male to male to female.       |
| 2      | Female to female to male.     |
| 17     | Female to male to male.       |
| 2      | Male to female to male.       |
| 5      | Female to male to female.     |

It should be noted that most of the oysters in which the sex was determined in 1931 and 1932 were two or three year old oysters when first recorded.

Consideration of the last two tables shows that there is a considerable variation from oysters which remain of one sex throughout the period to oysters which change sex every year. There are indications that the behaviour of these captive oysters is not quite the same as it would be on the natural beds, but it

is probable that some of the oysters change sex each year although the general tendency is from male to female.

Effect of Crowding on Sex of Oysters.

It was noted in 1933 that there were indications that crowding might affect the sex of the oysters even if it was not sufficient to stunt the growth. To test this a number of oysters were suspended individually on wires while the control oysters were placed in wire baskets, rather crowded together. All these oysters were kept until the breeding season of 1934 but, unfortunately, many of the floats supporting the wires became water-logged over winter so that the experiments were almost worthless and will have to be repeated. In some of the strings the oysters were sunk in mud and there was such poor growth and so many deaths that it is not worth while to record the sex of the remainder. In the following cases the mortality was not so high and the growth was fair.

Table V. Effect of crowding on oysters ♂ in 1933.

| Number in<br>1934. | Oysters suspended<br>individually |      |        |      | Oysters kept together<br>in baskets. |      |        |      |
|--------------------|-----------------------------------|------|--------|------|--------------------------------------|------|--------|------|
|                    | Female                            | Male | ? Dead | Dead | Female                               | Male | ? Dead | Dead |
|                    | 8                                 | 7    | 2      | 2    | 11                                   | 15   | 7      | 2    |

Table VI: Effect of crowding on oysters, sex undetermined, in 1933.

| Number in<br>1934. | Oysters suspended<br>individually |      |        |      | Oysters kept together<br>in baskets |      |        |      |
|--------------------|-----------------------------------|------|--------|------|-------------------------------------|------|--------|------|
|                    | Female                            | Male | ? Dead | Dead | Female                              | Male | ? Dead | Dead |
|                    | 10                                | 30   | 6      | 2    | 33                                  | 100  | 4      | 17   |

Consideration of these tables shows that there was very little difference between the oysters that were kept individually, and those that were somewhat crowded. But these experiments are

regarded as inconclusive for the reasons given above, and because too few oysters whose sex was known in 1933 were available for experimentation. The experiments are being repeated over the season 1934-35 and, of the oysters kept in baskets, some are only crowded with other oysters and some by mussels as well.

#### Discussion.

The observations of oysters from Totten bed over several years have given some very interesting records to support sex ratio observations on the natural beds. There is no way of telling how many of the oysters change from male to female each year for experiments have shown that they can easily change in the other direction, and it is probable that a number of them do this. But there is certainly a strongly marked tendency from male to female as the oysters get older.

So far the oysters kept for experiment have not shown the same general tendency as those on the beds, for a higher proportion of them have remained or become male than have remained or become female. This tendency was less marked among the oysters kept from 1933 to 1934 than ever before but it was still evident. It was suggested in 1935 that this might be due to crowding amongst the captive oysters but the idea still remains to be proved.